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PHONO PICKUPS

This issue of the REPORT represents a bit of an innovation as far as we are concerned. The entire issue is devoted to phono cartridges, arms, and test records. We would prefer to unify all issues in a similar fashion, but this is not practical for most types of equipment. In the case of cartridges, it is highly desirable (necessary, in fact) to test them all on the same record or records, and to have as many as possible available at the same time for A-B listening companions. This leads naturally to the simultaneous accumulation of a considerable mass of data which is easily presented at one time.

We unfortunately cannot cover the entire cartridge field at one blow. Space considerations, for one thing, limit us severely. We would like to test several other cartridges and arms (Ferranti, B-J, E-V ceramic, etc.) and expect to do so in the future.

Before treating each make individually, we will discuss the basic types of cartridges and point out their advantages and disadvantages.

There are two basic types of phono cartridges - the amplitude responsive and velocity responsive types. Ideally, the former will deliver an electrical voltage proportional to the amplitude of its stylus displacement, whereas the latter generates a voltage proportional to the instantaneous velocity of the stylus. The employment of constant amplitude and constant velocity recording characteristics on disc recording was described in some detail in the January 1955 issue of the REPORT and will not be repeated here.

AMPLITUDE-RESPONSIVE PICKUPS

Pickups falling in this category include the piezo-electric types (crystal and ceramic), the capacitance types (Weathers) and strain sensitive types (Pfanstiehl and the never-marketed RCA 5734 mechano-electronic transducer).

For many years, piezo-electric pickups have been the most widely used type in cheap (and sometimes not so cheap!) home phonographs and combinations. They are quite rugged, inexpensive, and generate a high output voltage (0.3 to 4 volts, depending on type) which makes a high gain preamplifier unnecessary. Furthermore, as we pointed out in January, most records are not too far from having a constant amplitude characteristic, so no external equalization is required. High frequency response is entirely determined by the pickup design and low frequency response can be controlled by the value of resistance used to terminate the cartridge - the higher the resistance the better the bass.

Up to now, most piezo-electric pickups have employed a Rochelle salt crystal, which generates a voltage as it is bent. The stylus assembly, through various types of mechanical linkages, serves to bend the crystal in conformity with the groove modulation. Two severe handicaps have resulted from this - the stiffness of the crystal means a low compliance at the stylus tip, and the moving mass of the stylus/crystal assembly is generally quite large. The former property causes the resonance of stylus compliance and arm mass to be rather high in frequency, thus preventing truly extended low frequency response and generally impairing tracking of low frequencies. The latter serves to limit the high frequency response by resonating with the compliance of the record material at a low frequency which may be as low as 4kc, in cheap cartridges. Both factors also greatly increase record wear, needle talk, and distortion. Radically improved designs, use of newer materials, plus the economic incentive now present will result eventually in crystals in the same league as the magnetics.

Issues 6 and 7 were combined for continuity of subject matter

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Rochelle salt crystals deteriorate rapidly in temperatures above 100°F. and are subject to fracture if handled roughly. Since the war, other types of artificially grown crystals have been used, none of which has yet changed the basic situation appreciably. The ceramic cartridges employ a barium titanate element which behaves quite similarly to a crystal, but is much longer lived, rugged, and insensitive to any temperatures found in proximity to phonograph systems.

In recent years we have seen several ceramic cartridges (and a few crystals) which come close enough to our conception of high fidelity to merit serious consideration. The Sonotone Titone pickup was, in large measure, responsible for the remarkable performance of the original Columbia 360 phonograph. Their latest models (reported on in this issue) offer a pretty good degree of fidelity at low cost. Electro-Voice is producing a ceramic cartridge which is claimed to be the equal of any magnetic cartridge. We haven't tested one yet. Also, on the market, are so-called high-fidelity crystal cartridges by Collaro and Ronette. We've listened to the Collaro Studio "O", and while it's pretty good for a crystal, it will not stack up against any of the magnetic cartridges. Ronette (manufacturers of the Collaro) under their own name, makes the best crystal cartridge we have thus far tested.

One advantage of the piezo-electric (and some other types of amplitude responsive cartridges, is that they are not subject to induced hum from the turntable motor, power transformers, etc. On the other hand, being high impedance devices, they are very subject to electrostatic hum pickup and must be carefully shielded. A cheap two pole phono motor, which will induce an intolerable hum in a magnetic cartridge will not bother a piezo-electric cartridge at all - hence their exclusive use in any but the finest commercial phonographs and combinations.

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The capacitance pickups function by having the stylus act as one plate of a small capacitor. Motion of the stylus varies the spacing between it and the fixed plate, and thereby the capacitance between them. In the Weathers system, this capacitance modulates the frequency (and to some extent the amplitude) of an RF oscillator in the 20 megacycle region. By a very simple self-detecting oscillator circuit, these variations are converted to an audio output voltage. An output of a few tenths of a volt is obtained. This type of pickup is inherently linear, although its detection system may not be. The Weathers system is discussed more fully in a later issue of the REPORT.

The Pfanstiehl cartridge employed a plastic vane on both sides of which high resistance coating was applied. Flexing this vane via the stylus caused the resistance to increase on one side and decrease on the other. A DC current was passed through these resistances, whose variations produced a variation in DC voltage proportional to the displacement of the stylus. This is a common technique in industrial strain gages, from which this cartridge was derived. Its output was low, comparable to the magnetic cartridges, and a special preamp was needed due to its amplitude responsive nature. Unfortunately, it is no longer made, in spite of what sounded to us like quite satisfactory hi-fi performance.

The 5734 tube was never used commercially, though an improved design of it might be interesting. It is a small cylinder, 1.3" long and 1/3" in diameter, with a 1/8" rod protruding from one end and 4 wires from the other. Inside was a triode vacuum tube whose plate-to-grid spacing could be varied by angular displacement of the 1/8" shaft. The resulting plate current variation permitted an output of 20 volts or more to be obtained from a 78 RPM record when a stylus assembly was soldered to the shaft. Naturally, this tremendous output could drive many power output stages directly, with obvious simplification of amplifier design.

Its disadvantages were several:

(1) Very low compliance

(2) Self resonant frequency of 12 kc, which was lowered by addition of a stylus assembly

(3) High temperature of tube envelope, plus need for carrying heater and plate power through the arm

(4) High cost - $18.00.

We have one lying around our lab., but wouldn't dare apply it to an LP record. The idea still appeals to us, if a low mass, high compliance version of this tube ever appears.

VELOCITY-RESPONSIVE PICKUPS.

All magnetic cartridges are velocity-responsive. They utilize the fact that when there is a change in the magnetic flux linking a conductor, either due to a change in the total flux or to a motion of the conducting wire through the field, a voltage is generated in the conductor whose amplitude is proportional to the rate of change of flux linkages and to the length of wire cutting the field (or the number of turns if the wire is in the form of a coil). In other words, the output of a magnetic cartridge is proportional to the velocity of the moving element, the strength of its magnet, and the number of turns of wire in its winding.

Moving coil magnetic cartridges have been in use for many years, since the infancy of electrical recording and reproduction. They were standard for many years in broadcast and wired music applications. Until a few years ago, they were characterized by high price and mediocre high frequency response. Types developed since the advent of LP records have completely reversed the situation, with a number of currently available makes providing response well beyond the limits of audibility. Three makes of moving coil cartridges are currently being sold for hi-fi use in this country. The Fairchild line was the first to be introduced a few years back. It has undergone several modifications, but the basis of its design is a small (about 1/8" long x 1/16" diameter) coil of extremely fine wire, fastened in a compliant support at one end and driven by the stylus at the other end. This "wig-wag" motion through a very powerful magnetic field generates a low voltage (compared to the variable reluctance types) of about 3 to 4 millivolts in the older 215 series, and 6-7 millivolts in the new 220 series.

A step-up transformer can be used with either of these to boost the output for use with low gain preamps, though we have found that even the 215 series provides more than enough output for almost any preamp without a transformer. An advantage of this type of cartridge is low impedance (70 ohms for the 215, 170 ohms for the 220) which effectively acts as a short circuit on the preamp input and reduces the input circuit hum level considerably. This usually more than makes up for any hum increase resulting from operating the gain control at a higher setting. This impedance is virtually all resistive, so the effects of cable capacitance on response are virtually nil. No shielding is necessary for any reasonable length of input cable, and terminating resistance is immaterial. The small size of the coil in the cartridge means very little hum pickup by induction from the motor field.

A slight warning is in order - the Fairchild cartridges have a strong external field which can greatly increase the effective stylus pressure if a steel turntable is used (as on most record changers). A foam rubber pad on the turntable is the easiest way to get around this difficulty.

Last year Electro-Sonic Laboratories introduced a series of moving coil cartridges, based on a D'Arsonval meter movement. A long, narrow coil is mounted vertically between the pole pieces of a magnet, pivoted at top and bottom. A small "shoe" of very thin metal extends horizontally from the bottom of the coil and the stylus is mounted at the tip. Lateral motion of the stylus rotates the coil through a small angle and generates a voltage in it. This voltage is even lower than the Fairchild - ESL advertises 1 mv minimum output. This is exceeded in practice on all their cartridges we have tested. A 10:1 step-up transformer is available for this, and is likely to be needed with most preamplifiers. We were able to get full room volume with a 2-tube preamplifier even without a transformer, but some systems may not be able to do this.

The resistance of the ESL cartridges is 1.5 ohms, so everything we've said about the advantages of the Fairchild apply as well to ESL (if not more so). The magnet, though strong, is so oriented that negligible pull is exerted by a steel turntable.

The Ferranti ribbon cartridge is actually a moving coil cartridge with a 1/2 turn coil. It must be used with its special unique arm. Output is very low and a transformer is necessary. We have not tested this unit so cannot comment at this time on its properties.

The other type of magnetic pickup - the so-called "variable reluctance" type, was first marketed for home use by G.E. in 1946. Subsequently other makes appeared operating on the same princi-

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ple, though with considerable variations in structure. These include Pickering, Audak, Clarkstan, and short-lived entries by Astatic, Lear and possibly a few others.

This type of cartridge has a fixed magnet and coil structure. A gap is provided in the magnetic path, introducing a considerable reluctance (the magnetic equivalent of resistance). The stylus serves to move a small piece of magnetic material in this gap, causing the reluctance to decrease or increase, depending on its proximity to one of the pole pieces between which the gap exists. This varies the amount of flux linking the coils and thus generates a voltage in them, proportional to stylus velocity.

There are several advantages to this design. The coil can be made quite large, so a considerable voltage can be induced in it. The coil and magnet are mechanically very rugged, as contrasted to the moving coil types which are somewhat delicate and fragile due to the fine wire and the fact that the coil itself must move. Most variable reluctance types have stylii which can be easily replaced by the user, whereas all moving coil cartridges must be returned to the manufacturer for stylus replacement.

Naturally, there are drawbacks as well. The necessity for moving a piece of magnetic material (which by the nature of things must be a heavy material) means a large moving mass, with resultant reduction of the high end response. Any stylus capable of replacement in the home is likely to be a fairly rugged device, with a low compliance. This impairs the performance of the cartridge at low frequencies and increases needle talk and record wear. The Pickering cartridges do not have replaceable stylii, since the manufacturer feels that the performance they have designed into the cartridge could not be guaranteed if the stylus were replaceable by the user.

The large coil has considerable inductance. This means the cable between cartridge and preamp must have the lowest possible capacitance to avoid cutting off high frequencies. The cable must be shielded, due to the relatively high impedance of the coil. These two factors work against each other and some compromise must be reached. In general, a resonance of cable capacity and cartridge inductance will occur somewhere between 8 and 20kc. To prevent an objectionable peak at the resonant frequency, a shunting resistor of the correct value must be used across the cartridge. Here again, a compromise is necessary since too high a resistance will result in a peak in the upper end response, and too low a value will cause loss of highs. Each manufacturer has his own recommendations, (i.e. 47k for GE, 39k for Audak, 27k for Pickering) which are usually quite close to the optimum. Frequently, though, some improvement can be effected by trimming the terminating resistance to match the particular cartridge and cable capacitance you are using. A good frequency test record and vacuum tube voltmeter are invaluable for this operation, unless you are the possessor of a truly "golden ear".

HOW THE AUDIO LEAGUE TESTED CARTRIDGES

We had suspected for some time that the performance of a phono cartridge could not be completely described by a frequency response curve any more than the sound of a speaker system. Early in our testing program, our suspicions were confirmed. One can make an educated guess on the basis of response curves as to which cartridges are better than others, and even to some extent predict the nature of the audible differences between certain cartridges. Nevertheless, the approach is completely inadequate to describe the subtle differences between a number of the finer cartridges on today's market.

The A-B test is the only sure way of evaluating differences between cartridges. By means of instantaneous switching between two cartridges playing the same record, it is fairly easy to discover even the more subtle differences. This general approach is still usable when a few seconds elapse between listening to cartridge A and cartridge B, though even the smallest interval makes accurate judgment difficult and more than 15 seconds or so probably will render the comparison invalid.

While a description of the difference between two cartridges may be of considerable aid to a prospective purchaser, the ultimate test of performance is to listen to a cartridge under normal home conditions for extended periods of time. It is rare indeed to find a cartridge which is 100% satisfactory after a few months of use. As one becomes accustomed to its sound-quality, obscure distortions and hard-to-explain sounds become apparent. The search for a new and better cartridge is then initiated. This cyclic process of improvement in the quality of one's music system is quite common among audiophiles, and is by no means limited to the phono transducer!

To a greater or lesser extent, The Audio League employed all three methods of cartridge evaluation. All cartridges were tested with the Cook Series 10 and Folkways FPX-100 frequency test records, and the Cook Series 50 IM test record. Two turntables (Collaro #2000 and Rek-O-Kut T12) were set up in such a manner that a number of arms could be set up around them for A-B comparison purposes. The Fairchild 281 arm was used for testing most of the cartridges because of the ease of plugging in the cartridge drawers. This permitted cartridge switching with less than a 5 second dead interval. A B-J arm was received late in our testing program, and was used for testing the Sonotone cartridges. The Pickering 140 was tested in a Pickering 190D arm; the 260 was plugged into our Fairchild arm. The ESL Professional cartridge is designed for their model 310 arm, so the two were used together. The Weathers Debonnaire system of course included a Weathers arm, as well as a modified G.I. Model DSS turntable and a preamplifier. This was tested as a unit, though it was compared to other cartridges in A-B listening tests. This will be reported on in a future issue.

The Audak was mounted in a homemade wooden arm, similar in basic design to the Pickering 190 but with a mounting for the Audak cartridge. Ordinarily these units must be used in an Audak arm or one of the record changers which can use modified plug-in shells.

The cartridges were electrically terminated in the manner recommended by their manufacturers for flattest response. No attempt was made to experimentally determine a load value which might have improved the performance of any individual cartridge. Employment of special techniques were necessary with the Weathers system.

The GE, Audak, Pickering 140, Fairchild 215, and one Fairchild 220 cartridge were purchased through distributors in the normal fashion, as were the Fairchild 281 arm and the Pickering 190D arm. The ESL units, Pickering 260, Sonotone, three Fairchild 220 cartridges, Weathers Debonnaire, and the B-J arm were supplied to us by the manufacturer or importer. Nothing in our examination or test of any of these units indicates that they differed in any way from those sold through the usual channels.

The Audak R-2 is an obsolescent type, though we have measured its resistance and inductance and found them identical to the published figures for their more recent DL-6. It was equipped with a so-called "chromatic" diamond stylus, presumably identical to those supplied with the

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How Cartridges Tested, cont.

DL-6 and the newer HiQ-7. We present the data on the Audak cartridge for what it may be worth, though we realize it may not necessarily apply to their latest models.

Similarly, the Pickering D-140 is an old type. We believe Pickering is still making them, but we can see little likelihood of production being continued too long in view of the superior performance of the newer 220/240/260 series.

Inasmuch as we are (for the moment, at least) interested only in cartridge performance, we made our response measurements from 1000 cycles up. No preamplifier was used - the cartridge was terminated in the recommended resistance and its output measured directly in millivolts on a Hewlett Packard #400-C vacuum tube voltmeter.

When using variable reluctance cartridges, it is important to keep shunt capacitance (from the shielded cable and other sources) below about 250 mmf if high frequency attenuation is to be avoided. Our cable capacitances were kept below 150 mmf.

In the case of the Sonotone cartridges, the entire range of the test records was utilized, with the only termination being the 10 megohm input resistance of the meter. The Weathers, by virtue of its unique design, could only be used with its preamplifier. The knobs were set at the recommended points for various equalization curves and a Dubbings D-101 record was used as a means of comparison. The Dubbings record was further checked by playing it with a Fairchild 215A, whose flatness had been previously established.

TEST RECORDS

This report started out to be a survey of pickups. We soon found, however, that it was advisable to doubt one's test equipment (a healthy attitude in any laboratory measurement). A study of the available test records brought out several points which we felt would be of interest to many of our readers who might wish to check their own pickup.

The most practical way we know of to quantitatively measure pickup frequency response is by means of a test records, which has a series of single frequencies recorded on it at known velocities.

The record manufacturers (RCA, Columbia, British Decca, etc.) make test records which are useful in checking the equalization of a phono system. They are recorded with their own particular characteristic (RIAA, AES, or what have you) so that, when played back with a properly equalized preamp and a flat cartridge, a flat output is the result. Dubbings also makes a record with a number of recording characteristics on it. We are not concerned at this time with the applications of this sort of record.

The record manufacturers also make unequalized recordings (that is, constant amplitude below 500 cycles or some other given turnover frequency and constant velocity above that point - no pre-emphasis). This is the sort of thing we need, but unfortunately the records issued by the large record companies only go up to 10 or 12 kc. This is useless for checking any modern pickup.

For some time the Cook Series 10 record has been our standard, for lack of any other. This has recorded frequencies from 35 cps to 20 kc, plus intermodulation bands and sweep frequency bands. We had noticed a disturbing tendency of almost all cartridges to show peaks in the region from 9-12 kc, and attempted to calibrate our test record by the optical method (see p. 672, The Recording and Reproduction of Sound, (Second Edition) by Oliver Read for further details of this technique). This showed sizeable departures from flat response above 9 kc, but not easily correlated with our electrical measurements.

A recent paper presented by B. Bauer of Shure Bros. Inc. before the Institute of Radio Engineers National Convention indicates that the visual determination of recorded velocity is subject to appreciable error above 10 kc, and a special photographic technique is required for accurate results. This explains some of the discrepancies we observed between the optical calibration curves of our records and the electrical outputs of our cartridges.

We bought another Cook Series 10 record, whose optical pattern and measured performance with various cartridges proved to be identical to the first. At this point we acquired a record issued by Folkways Records, FPX-100, entitled "Sounds of Frequency". This is perhaps the most complete test record we've seen, recorded by Peter Bartok. The frequency range is 15.6 cps to 22.5 kc, plus two IM bands, several bands for checking RIAA and Bartok equalization curves, and 100 cps and 1000 cps square wave bands. The latter appear to warrant an investigation in themselves, which we hope to undertake at some future date.

All of our cartridge tests have been performed with both Cook and Folkways records and the results of both are plotted for each cartridge. The peaks of the Cook Series 10 record are quite apparent when thus compared. When due allowance is made for these peaks, there is a marked similarity between both sets of tests.

There are still some differences, generally in the region above 10 kc. We attribute part of this to differences in the record materials used by Cook and Folkways. This effect is particularly striking in the case of the Audak cartridge, whose response cuts off above 12 kc on the Cook record and at 18 kc on the Folkways record! The Folkways record material must be considerably stiffer (less compliant) as its resonance with the cartridge moving mass falls at a much higher frequency than with the Cook record.

The recorded level is specified by Cook to be 9 cm/sec at 1000 cycles, which is equivalent to a fairly loud musical passage. The Folkways record is recorded with almost exactly the same velocity.

The Cook Series 10 has a large number of frequencies, spaced not more than 1 kc apart below 10 kc and every 2 or 3 kc from 10 to 20 kc. This close spacing is ideal for plotting a cartridge response in some detail. The Folkways record, on the other hand, has its tones spaced at half-octave intervals. This is justifiable on many grounds, though it does introduce the possibility of overlooking some of the peaks which may fall between the test frequencies in the upper frequency regions.

In addition to frequency response, one would like to measure the distortion generated in the cartridge. Both the Cook Series 10 and Folkways FPX-100 discs have IM bands recorded on them. Cook uses frequencies of 100 and 7000 cycles, with the standard 4:1 amplitude ratio. Two bands are available, with recorded peak-to-peak amplitudes of .0045" and .0028". Residual IM distortion on the record is stated to be less than 4% on the former band and 2% on the latter. Folkways features a slightly different arrangement. Two bands are provided, containing 16 kc and 8 kc tones, modulated by 60 cycles. In a perfectly linear system, no 60 cycle component

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Test Records, cont.

should be audible when playing these bands. If any non-linearity is present, some of the 60-cycle modulation will be detected and become audible. In practise, we have found that the 60 cycle hum is audible with any cartridge we have tested with no particular differences between types observed. We are somewhat reluctant, therefore, to consider these bands of value in distortion measurement. In the case of the Cook record, an IM analyzer or the equivalent in the form of a high pass filter, detector, low pass filter and VTVM is needed to measure IM. This is clearly of no value to the average audiophile, though we have employed it in the past in our laboratory. These bands were not used in evaluating cartridges in the present survey.

A year or two ago, Emory Cook introduced what promised to be the answer to the great need for a distortion measuring record which could be used in the home without any instruments. This was the Series 50, or "N-A" Beam test record.

On this disc two sine wave tones of equal amplitude, spaced 1000 cycles apart, are recorded and swept down in frequency from 20 kc to 4 kc. One tone is keyed on and off with the Morse character "N" (dash-dot). During the "off time" a 1000 cycle pilot tone is recorded, with an amplitude of 2% of the average value of the combined carriers. The keying relationships result in the pilot tone taking the form of the character "A" (dot-dash).

If the intermodulation distortion generated in the playback system is less than 2%, the character "A" will be heard; if it exceeds 2%, the character "N" appears. (These may be considered as "Acceptable and Not Acceptable"). At exactly 2% distortion, both characters merge to form a continuous tone. Cook states that residual distortion on the records is generally less than 0.67%, except at 14 kc where it may be about 1%.

It should be noted that this record tests the entire playback system. Distortion generated in the amplifier or speaker system can produce an "N" even where the cartridge is blameless.

On the face of it, this looks like a real good idea. Well, it is, but no panacea for all that. We have tested many, many cartridges of all types in this manner. Two which have failed to pass were the Pickering 140 and ESL Standard. Both of these gave an "N" at 14 kc, where only 1% of cartridge distortion is sufficient to do the damage. Most others, including the Sonotone 1-P ceramic cartridges, passed easily, even though several of them were audibly inferior to the two which failed. A further hard-to-explain development is that we have been unable to make even the lowest priced tweeters, such as the University 4401, fail the test even when driven far beyond their rated power levels. Our ears gave out before we could produce an "N".

We have therefore concluded that the Cook Series 50 record is of limited value in detecting pickup or speaker distortion. A far more sensitive test is simply listening to records that are known to be "clean" or comparing the cartridge in question by an A-B test with a standard cartridge known, by listening or other means, to have low distortion.

Incidentally, some of our readers have written to tell us of their difficulties in finding cartridges which pass the Cook Series 50 test. There is a certain knack which must be acquired in using this record. As the test frequencies get below 15 kc, one can hear the "N" of the carrier being keyed. This may sound much louder than the 1000 cycle pilot "A" but must be rigorously excluded from one's mind. Remember, the 1000 cycle pilot tone is the only one to listen to - disregard all the "N" signals coming from the keyed carrier.

This test is a rather sensitive indication of arm adjustment. We have found that even a slight error in arm placement (pivot to turntable center distance) can cause a perfectly good cartridge to fail the "N-A" Beam test. Any friction or binding in the arm bearings will likewise produce an "N". Perhaps the most valuable application of this record is in determining minimum pickup tracking force. The manufacturing recommendations are a good guide to start with, but the only true criterion must be whether or not the cartridge will track a record with low distortion. If a cartridge advertised as requiring 6 grams tracing force yields an "N" under these conditions, but on increase to 8 or 9 grams, changes this to an "A" (this will almost always show up in the 14 kc region), then the higher pressure is clearly indicated. On the other hand, if it passes with 3 grams, this should be used. In general, the lowest pressure which will pass the Series 50 record test and track heavily modulated low frequency passages without groove skipping should be used. The importance of using a good arm, properly mounted and carefully balanced, cannot be over-estimated.

Just a reminder that we do appreciate and read all of the comments you send in to us. Our files are fairly bulging with statistics on how many subscribers desire what equipment tested, and that's the way we like and need it. Please include your subscription identification number on all correspondence.

GE RPX-052

We have heard it said (and are inclined to agree) that the introduction of the GE variable reluctance pickup in 1946 had more to do with advancing the development of high fidelity as we now know it than any other single development since or before that time.

Prior to its development, the crystal cartridge was standard equipment on home phonographs and in many broadcasting stations. These devices seemingly were designed for purposes of record destruction -- 2-3/4 ounces was a common stylus pressure and 1 ounce (28 grams) was considered light weight. Even the most expensive professional playback equipment employed stylus forces far in excess of today's accepted values.

The early GE cartridge antedated LP records, and was equipped with a non-replaceable 3-mil sapphire stylus. Its price was less than $6.00, competitive with inferior crystal cartridges. After the advant of LP, the replaceable stylus was introduced, followed by the triple-play model, RPX-050. At a price of slightly over $8.00 for the dual sapphire stylus, or $22. for the diamond-sapphire combination, this provided in effect two cartridges, for standard and LP records, with a replaceable stylus assembly, containing both stylii. Tracking force was 6-8 grams on either stylus. Response was claimed up to 10 kc.

To ears accustomed to the sound of crystal cartridges of that day, the GE offered unprecedented smoothness, low needle talk, and relatively distortionless response. It rapidly became the mainstay of the phono pickup industry, which it is to this day.

Several years ago, the RPX-052 was introduced. Aside from a gold plated case, it differed from the RPX-050 in the nature of the damping applied to its stylii. Response was claimed up to 15 kc, with the improved damping yielding smoother performance.

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GE cont.

Last month, without fanfare or indeed any public announcement, GE made its most important improvement in years. Current models, identified as RPX-052A, are equipped with a stylus assembly containing two individually replaceable stylii. The major objection to the RPX-052 has been overcome. A similar redesign of the stylus assembly on the single cartridges means that only one type of replacement stylus is needed for all types of GE cartridges. The new stylus assemblies will fit older cartridges, and vice versa.

The reputation of GE cartridges in the field is generally good. It is recognized that there are great variations in frequency response and in output voltage among them. A selected GE cartridge is claimed by many to be the equal of any of the more expensive types. We have never heard of one sounding anything less than good. Their low price has kept them in the "best buy" category for years.

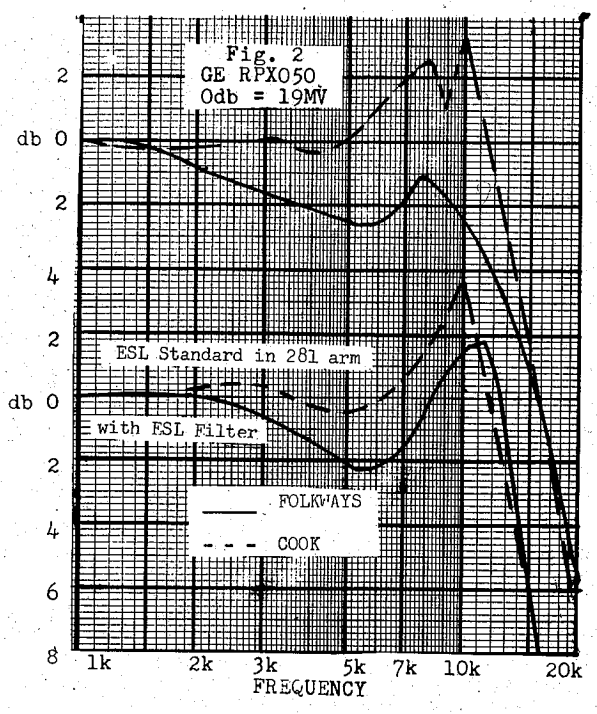
We tested a number of GE cartridges, including RPX-050, RPX-052, and RPX-052A. There were minor variations in output level (11 to 18mv) and all units showed very similar frequency responses. None had significant response much over 10kc. No marked audible difference could be discerned between old and new types. All sounded fine when listened to by themselves. In A-B comparison with some of the better cartridges, the lack of brilliance in the extreme highs, a slight degradation of clarity and definition in complex orchestral passages, and a tendency toward muddiness in the bass became apparent. This is not intended as an adverse criticism of the GE -- merely to point out that there are better cartridges, at a price.

The GE is as nearly foolproof and trouble-free as any device we know of. It is rugged and non-critical in use. A tracking force of 8 grams in a record changer or 6 grams in a good arm should be sufficient. Some attention should be paid to keeping the stylus shoe centered between the pole pieces, and to brushing lint and foreign matter away from the pole pieces. Neglect of these will result in distortion and poor tracking (similar precautions are called for with the Audak cartridges). The internal construction of the GE is such that there is virtually no hum pickup problem and no magnetic attraction to steel turntables.

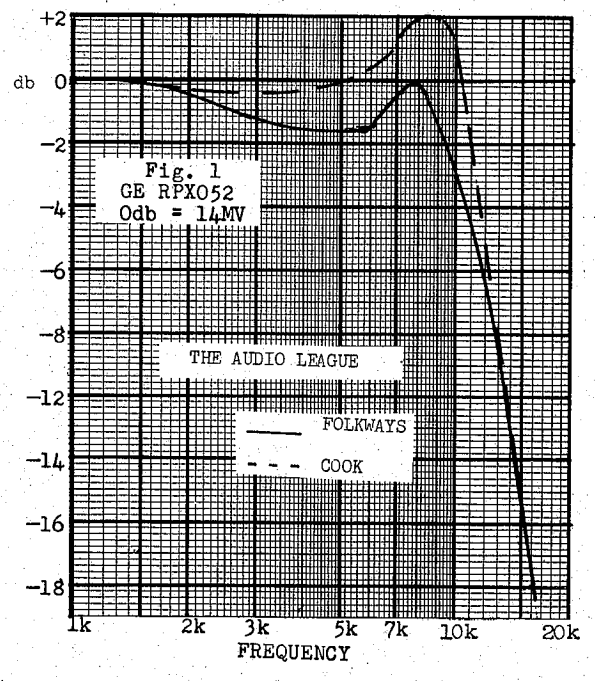
As is the case with any fairly high impedance magnetic pickup, excessive shunt capacitance will result in loss of highs. The frequency response is quite critically dependent on the value of terminating resistance. 47K will generally yield flattest response. It is possible to equalize the high frequencies by shunting the cartridge with a lower resistance. 15K will approximate the RIAA curve, 6.8K the LP curve. Shunting one of these resistors with a capacitor of the proper value will provide a sharp high frequency cut-off, useful for scratch reduction on noisy records. This is the method employed in the GE record compensators.

On an absolute basis, the GE must be rated near the bottom of the list of magnetic cartridges included in this report. It is good, but no match for ESL, Fairchild, or Pickering. When its low price is considered, however, the GE becomes an outstanding "best buy". Nowhere else in a hi-fi system will such a small expenditure of money bring such a large return of good sound. It has become an accepted fact that other low cost cartridges, piezo-electric or magnetic, are compared to the GE. To say of any low cost cartridge, "It sounds very much like a GE" is to pay it the highest compliment.

There is a GE Professional cartridge which is a low impedance model intended to operate with broadcast equalizers. Its output is correspondingly low, a few millivolts.



Inasmuch as the performance of this cartridge is almost exclusively a function of its stylus assembly, there is no advantage to using the Professional model. Its stylus is identical to the ones in the ordinary GE units. A number of broadcasting stations, including some of the outstanding high fidelity stations, employ GE cartridges exclusively, with generally superlative results. We suspect they use selected stylii, since the quality of their sound is somewhat above the run-of-the-mill GE sound in most home systems.



In response to numerous requests, we plan to reprint Issue No. 1 in the near future. Watch for announcements in coming issues.

PICKERING 140

For a number of years, the Pickering 140 (and its companion, the 120) has enjoyed a reputation as one of the top quality magnetic cartridges. It has now been superseded by the 220-240-260 series, but as a matter of general interest, we are including it in our survey of the pickup field. The 140 will undoubtedly continue to be available on the second-hand market for some time, and we know of people who prefer it to the newer 240 series.

Pickering cartridges are of the variable reluctance type, but differ radically from the GE and Audak in physical form. The magnetic structure is entirely contained within the cartridge case. The moving member is an aluminum sleeve at one end of which the stylus is mounted, and fastened flexibly at the other end. Only the stylus itself protrudes from the case, and the tube is surrounded by a damping jelly where it passes through the case. The cartridge must be returned to the manufacturer for stylus replacement.

One of the most striking features of the Pickering 140 is its unusually high output - 50 mv. at 10 cm/second velocity at 1000 cycles. Early models delivered 70 mv. This large output, 2 to 5 times that of competitive cartridges, meant in some cases lower hum levels, since the preamp gain could be set at relatively low values. This feature is a two-edged sword, however, since the output level of a Pickering 140 approaches the point at which the preamp may be overloaded, with resultant distortion. Most commercial preamps are satisfactory in this respect.

The natural armature resonance of a Pickering stylus assembly with the compliance of a vinyl record groove occurs in the vicinity of 8 kc. If the stylus damping is effective, a peak of a few db will occur at this frequency, with a fairly gradual roll-off above that point. Significant response can be obtained up to 15 kc. With the passage of time, the damping jelly loses its effectiveness and the 8 kc peak becomes more prominent. When the sound begins to be unpleasant or strident, it is time to return the cartridge to the factory for overhaul and new damping material.

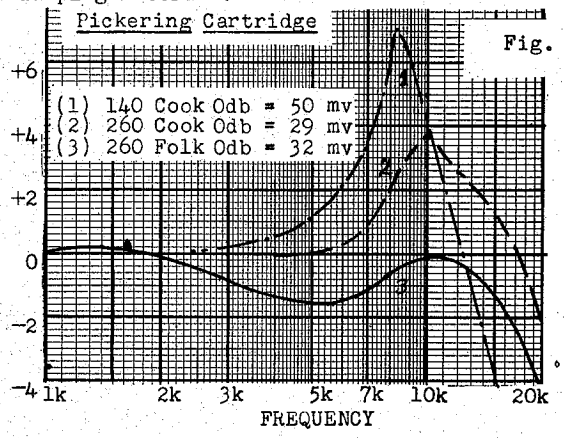


Fig. 3

Even when new, the sound of a Pickering 140 tends toward stridency. Many people prefer this type of sound. In comparison with GE cartridges, a considerable amount of "snap" and brilliance is imparted to the sound. If your speaker system is a little deficient in highs, or at least has no peaks in the vicinity of 8 kc, the Pickering 140 can be an outstanding cartridge. On the other hand, if a speaker peak should occur at 8 kc, the results can be unpleasant indeed. In addition to "screeching", the record hiss level will be greatly increased. This is also the effect of loss of damping in the cartridge.

In our tests with the Cook #50 record, the Pickering 140 was one of the few cartridges which failed to pass. A clear "N" was audible in the 13-14 kc region. In connection with this, we have seen a letter from a well known manufacturer of tone arms to a purchaser of his arm who complained of his Pickering 140 failing this test. The manufacturer stated that the Pickering 140 was inherently incapable of passing this test. We cannot vouch for the accuracy of this statement but offer it in corroboration of our findings. See comments in this issue on Test Records.

Another prominent characteristic of the Pickering 140 is its needle talk. We say "prominent" advisedly. The needle talk of this cartridge is the loudest of any magnetic cartridge we have tested. This is not surprising in view of the 140's high output. Getting high output from a magnetic cartridge means that the groove walls must do a lot of work on the stylus assembly. If tracking is anything but perfect, there is bound to be considerable acoustical energy generated at the stylus.

The Pickering 140, we feel, is a cartridge with a distinct personality. It colors the reproduced sound pronouncedly, and not necessarily detrimentally. Some of the finest reproduced sound we have ever heard has come from Pickering 140 cartridges - and some of the worst! This is a cartridge which should be auditioned before purchasing, if at all possible. In view of its replacement by the 220/240/260 series, this may be academic advice, but there may still be some 140's available on the market.

PICKERING 220/240/260

This series of cartridges is a further development of the older 120/140 series. The 220 has a 3 mil stylus; the 240 a 1 mil stylus. Mounted back-to-back in a turnover assembly, they become the 260.

The 240 is the smallest magnetic cartridge we have seen -- about the size of one's thumbnail. We believe its internal structure is similar to the 140, but scaled down considerably. (We've never opened one up to find out!). Certainly, the moving mass of the stylus has been greatly reduced, with the result that the resonance with a vinyl record occurs about 16 kc instead of 8 kc. The small size of the 240 makes it necessary to use an accessory clip to mount it, since there just isn't room on the cartridge for standard ½" mounting hole spacing. With the clip it will fit any standard arm.

The output of the 240 is still very high for a magnetic cartridge, though not quite as high as the 140. 30 mv at 10 cm/sec stylus velocity is Pickering's advertised figure, and that's just what we measured. Best of all, needle talk is greatly reduced, to the point where it is comparable to most other magnetic cartridges.

Our test cartridge was a 260 turnover model, loaned to us by Pickering. It was an unselected unit taken from stock. We mounted it in a Fairchild plug-in drawer for use in our 281 arm. The mounting of the 220 and 240 back-to-back to form the 260 is quite ingenious. The cartridges slip in and out of the clip without any tools or soldering operations. Inasmuch as we were only concerned with the performance of microgroove cartridges, we only tested the 240 cartridge.

As can be seen from the response curves, the 240 is vastly smoother than the old 140. Its response above 10 kc might be described as falling between that of the Fairchild 215 and 220 cartridges. The Cook Series 50 record was played with no suggestion of an "N" at any time. On listening tests, it ranked very close to the Fairchild 220. It was not easy to tell them apart in A-B comparisons, although after a little more extended comparison, various members of our listening panel were able to express fairly consistent preferences. (Neither one was considered clearly superior to the other by most listeners).

ELECTRO-SONIC LABORATORIES (ESL) CARTRIDGES

The ESL cartridge is a moving coil magnetic device, constructed like a miniature D'Arsonval meter movement. A relatively long, very narrow coil is pivoted at both ends so that it is free to rotate through a small angle. It is placed in a powerful magnetic field, and a small aluminum stylus shoe is attached to one end. Lateral displacement of the stylus at the other end of the shoe causes the coil to rotate slightly, and a voltage is generated in it proportional to the stylus velocity, just as in any magnetic pickup.

There are several outstanding characteristics of this cartridge. Since the coil is pivoted at both ends and is free to move around one axis only, there can be absolutely no response to vertical movement of the stylus. This is advantageous in reduction of noise, rumble and distortion in the output.

A minimum of damping is designed into ESL cartridges. Small latex blocks are used as pivots for the coil, largely to provide enough restoring force to keep the stylus shoe centered. A small amount of damping is supplied by these blocks, but generally the resonance of stylus moving mass and record compliance is allowed to go unchecked. This will be discussed in more detail later.

The lateral compliance of these cartridges is greater than any other we know of except the Weathers. The Standard series, designed for record changers, has a compliance of 4.43×10^{-6} cm/dyne, which is barely exceeded by the Ferranti. The Concert and Professional ESL cartridges have compliances of 7×10^{-6} cm/dyne.

The moving mass of the ESL units is far less than other magnetic cartridges (3 mg. for the Standard, 1 mg. for the Concert and Professional). These low masses have not been approached by any other cartridge we know of except Ferranti and Weathers, who claim 2.5 mg and less than 1 mg. respectively.

ESL cartridges have an impedance of 1.5 ohms, essentially resistive, and a minimum output of 1 mv. The outputs of the units we tested varied from 1.2 to 2.4 mv, but since it is difficult to control the output level in the manufacturing process, ESL merely specifies a minimum level.

Although some preamplifiers have sufficient gain to operate directly from the cartridge output, most users will find it desirable to use the ESL 201 step-up transformer. This yields approximately 15 mv output at a 200 ohm impedance level. Even when using this transformer, there is no problem of shunting capacitance or terminating resistance affecting the response or output level. We could detect no degradation of quality, frequency response or hum level when using the 201 transformer. A type 211 transformer is also available giving an output of over 200 mv. This is too great for conventional preamplifiers, so we doubt that it will find any general application. It is noteworthy that even with the enormous step-up ratio of this transformer, our measurements showed no degradation of performance or hum level.

ESL makes available three series of cartridges, all similar in basic design. The Standard series is rugged enough to be used in record changers, yet has a lateral compliance of 4.43×10^{-6} cm/dyne and an equivalent stylus mass of 3 mg. The high compliance should add substantially to the low frequency response of the system when used in a record changer. (We did not test ours in a changer). Unfortunately, the resonance of the stylus mass with record compliance occurs at about 10-15 kc, depending on the particular test record used. The amplitude of this peak, being undamped, is considerable (8-12 db). As a result, the sound is rather edgy, with a noticeable record hiss. The Cook Series 50 record gave an "N" at 14-15 kc in our tests of this cartridge, indicating that the almost undamped resonance was impairing the tracking.

ESL suggests the use of a simple R-C filter in the transformer output to attenuate the high frequencies above 10 kc or so. They state that their cartridges are capable of considerable output in the 30-40 kc region which may overload some amplifiers if not attenuated by such a filter. We found a vast improvement in the smoothness of response of the Standard series cartridge when using this filter. The peak was reduced to 2.5 - 4 db and the edginess and record hiss disappeared. Of course, this does not affect the tracking ability of the cartridge at all, since the resonance is still there. When the filter is used, the overall response of the cartridge is very close to that of a GE, perhaps a bit better in the highs. We did not directly compare this cartridge to a GE, however. A-B comparisons were made with the ESL Professional series, Pickering 140, Fairchild 215 and 220. In the opinion of all who heard these tests, it was not the equal of any of these cartridges. Its needle talk is fairly low, comparable to GE.

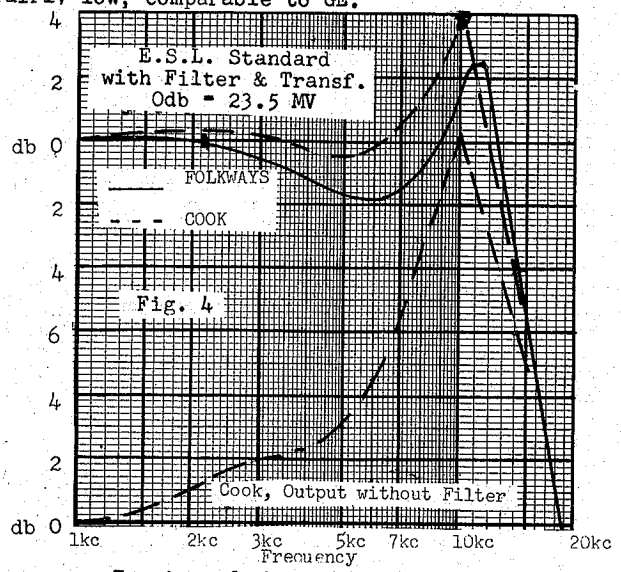
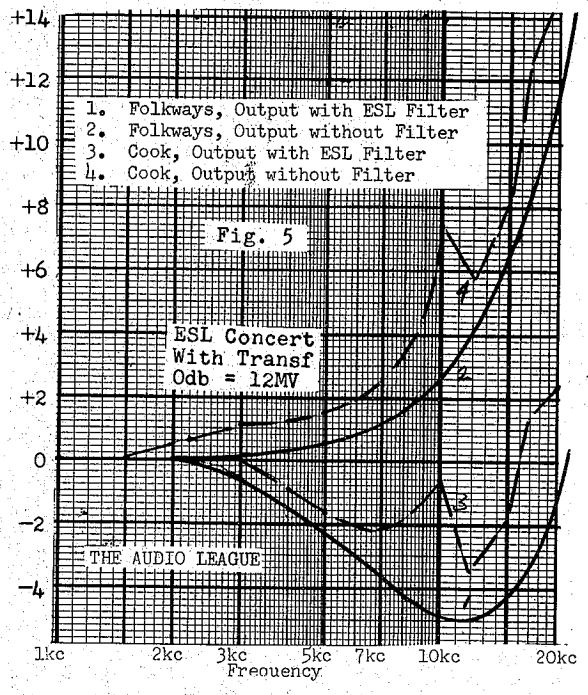


Fig. 4

In view of the price of this cartridge, ($30. plus $7.50 for the 201 transformer or $15. for transformer and filter), we do not feel its performance is high enough to warrant its purchase instead of a GE, for example. We realize that its high compliance and low mass may be of substantial benefit in prolonging record life, but pending a thorough investigation of this subject, we cannot evaluate the extent to which this advantage would justify the extra expense.

The Concert series cartridge is physically very similar to the Standard series. The coil is much smaller and the stylus shoe is a fraction the size of the Standard. They claim a compliance of 6.68×10^{-6}cm/dyne and an equivalent mass at the stylus of 1 mg. The vertical compliance is also much greater than that of the Standard series. The resonance of this cartridge is in the vicinity of 21-22 kc, and is of the order of 15 db. The rise is a gradual one, starting around 5 kc and, since the peak is well above the upper limit of human hearing, the hiss level is phenomenally low (virtually inaudible). When the filter is used, the response of this cartridge is within plus or minus 3 db from 15 cycles to over 22.5 kc. By a slight modification of the R-C filter constants, the slight depression in the 4-15 kc region could be eliminated and one could doubtless equalize the response to be within plus or minus 1 db over the audible range. We don't know if the audible sound would be improved by such a

change, not having tried it. Needle talk is practically inaudible, even a few inches from the cartridge. The smoothness and clarity of this cartridge are unique. By a practically unanimous decision, our listening panel considers the ESL Concert cartridge to be by far the finest phonograph reproducing instrument we have heard. In A-B comparisons with Fairchild 220 and Pickering 240 cartridges (its closest competitors) even persons who had never previously been exposed to high fidelity reproduction were struck by the superior definition of the ESL. Since its price ($36.) is the same as, or less than, its worthy competition, it would seem that anyone who can afford any good quality cartridge equipped with a diamond stylus can enjoy the superlative performance of this pick-up.



There is one slight disadvantage to this unit (apart from the need for a transformer). It is definitely delicate in construction and must be used in a good arm. We used it on the Fairchild 281 and Pickering 190D with excellent results. Even so, we suspect it should be handled with more care than the Fairchild or Pickering cartridges, though we did not have any unfortunate experiences to confirm our suspicions. This is no device for a heavy-handed audiophile!

The lateral compliance of the ESL Concert cartridge results in markedly superior low frequency response. The arm resonance in our Fairchild 281 arm was in the vicinity of 9 cycles, and only a 5 db rise occurred at that point. Output is virtually flat down to the lowest musical notes one can encounter (16 cps).

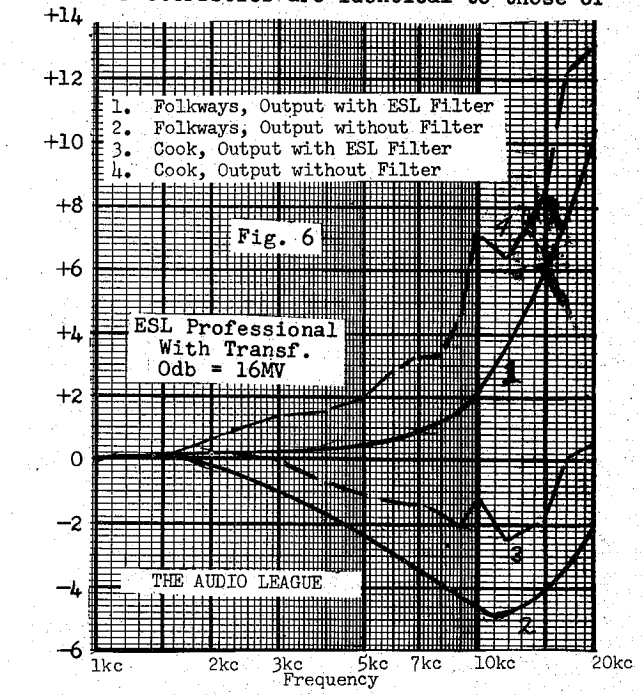
Incidentally, the record hiss, already at a new low, completely disappears when the filter is used. Even at the highest volume setting one has to put one's ear against the speaker to find any trace of hiss, and we suspect this is largely pre-amp. tube hiss.

The unusual flatness of the frequency response gives this cartridge a somewhat different sound from any of the others which have peaks in the audible range. In fact, compared to the Pickering 140, for example, it sounds quite dead. A few minutes of listening will convince almost anyone that this "deadness" is really a lack of coloration. If you like sizzling, flashy highs or pounding bass, this may not be your dish. For sheer naturalness and undistorted ease, it has no peer.

Satisfactory tracking was obtained with 2 grams stylus force in the Fairchild arm, but to make the playback set-up less subject to jarring, we operated it at 4-5 grams during our tests.

The physical structure of ESL cartridges offers one advantage which they share with Audak - the stylus is clearly visible from the front and cueing to the exact groove desired is a simple matter, at least in the Fairchild arm. In the Pickering arm, the cartridge is pretty well out of sight, as well as being offset at an angle. Cueing any cartridge in this arm calls for a knack which we haven't mastered, though with practice it can be done.

The ESL Professional series cartridge is somewhat of a connoisseur's item. Its performance characteristics are identical to those of



the Concert series. (The response curves can be superimposed and one can't be told from the other). It is physically much larger, made with a great deal more care and with tighter control of output level, and must be used with the special ESL Professional arm. The arm and cartridge sell for $106., which will rule them out for most people. The arm is reviewed separately elsewhere in this report.

The basic ESL pickup design is covered by Danish patents, and the Professional series cartridges and arms, as well as the ESL step-up transformers, are manufactured in Denmark. The workmanship of these cartridges is exemplary. The only respect in which their sound differs from that of the Concert units is in the needle talk. It isn't practically inaudible - it just isn't! For the Audiophile who can afford the best and wants something a little better, we recommend the ESL Professional series.

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FAIRCHILD 215A and 220A

The Fairchild cartridges are of the moving coil type. A small coil, approximately 1/16" x 1/8" is hinged at one end and connected to the stylus at the other end. It is located in a powerful magnetic field which generates a voltage in the coil directly proportional to the stylus velocity.

A properly designed moving coil cartridge is inherently linear, as compared to any of the moving iron or variable reluctance types. The non-linearity of the latter, stemming from the non-linear magnetic properties of iron, has been played up by manufacturers of moving coil cartridges, as well as some of the others. While recognizing the theoretical validity of these claims, we are by no means convinced that the distortions inherent in a variable reluctance cartridge are significant compared to those found elsewhere in the chain of recording and reproducing components.

The stylus member of the 215A (the older, now obsolescent model) passes through a thin rubber diaphragm which acts as a seal against foreign matter entering the cartridge and as a damping medium. The newer 220 series has the diamond stylus mounted on one end of a shoe, from the other end of which the coil is driven. A rubber damper and sealer is also used on this model.

One of the major benefits of this design is the reduction of moving mass referred to the stylus tip. The diamond and the thin aluminum tube in which it is mounted constitute almost the entire moving mass, since the coil is pivoted at one end and merely "wig-wags" as the stylus is moved. The reduction of moving mass is instrumental in extending the high frequency response, as well as reducing record wear.

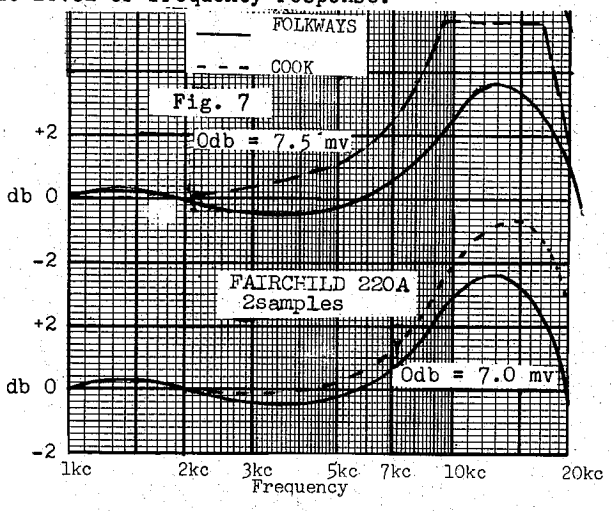
The magnets used in Fairchild cartridges are extremely powerful and are so oriented that the actual stylus pressure, when playing a record on a steel turntable, may be several times the proper value. Fairchild instructions for use of their cartridges mention this fact and its cure--the use of a foam rubber pad at least 1/8" thick on the turntable. Of course this problem does not exist with aluminum, brass, or other non-ferrous turntables.

When the 215 series was introduced a few years ago, it featured a higher compliance than any of its contemporaries (1.8 x 10^{-6}cm/dyne). The principal advantages of this were better tracking, improved low frequency response (due to a lower frequency of arm resonance) and reduced record wear. The 220 has even higher compliance than the 215, though the figures are not advertised. All the better cartridges today have stylus compliances considerably greater than earlier types, but few of the advertisements quote any specific values.

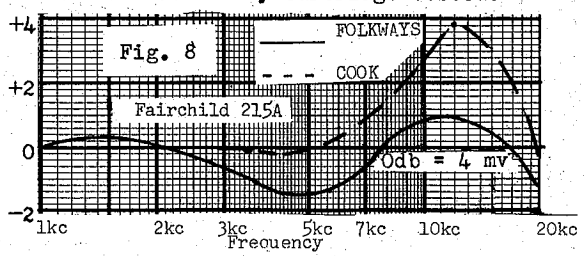
The 215 had a rated output of 3 mv., at least 10mv lower than the GE cartridge. A step-up transformer was sold by Fairchild, which increased the cartridge output to approximately 30mv. In practise, almost any commercial preamplifier of reasonably good quality has sufficient gain to eliminate any need for a transformer. In some case, the action of the loudness control may be impaired due to the gain being far advanced at normal listening levels.

Among Fairchild's claims for the 215 are (1) reduced arm resonance and improved low frequency response (see our discussion of arms elsewhere in this issue); (2) reduced record and stylus wear (this will be the subject of a separate investigation); (3) reduced record hiss (this is very noticeable due to the freedom from peaks in the audible range); (4) reduced needle talk (in some arms this is true ; in our Fairchild 281 arm, the needle talk was tremendous. Its volume was comparable to that of a Pickering 140, but it was much cleaner sounding. We suspect some sort of acoustic transmission down the hollow tube of the arm); (5) reduction of distortion (we found the clarity and freedom from distortion even in playing the loudest passages to be most striking when compared to GE, Audak, and Pickering 140 cartridges. Some records which we had considered sub-standard when played on other cartridges were clean and pleasant when using the 215A. Needless to say, the Cook Series 50 IM test was passed easily by this cartridge).

The impedance of the 215 is 70 ohms, almost purely resistive. This has several advantages. A rather long, unshielded lead can be used from cartridge to preamp. without fear of hum pickup. Hum pickup in the cartridge is virtually nil, due to the small dimensions of the coil. Capacitance shunting the cartridge has no effect on frequency response; the cartridge is basically non-resonant. For the same reason any value of terminating resistance, from 5000 ohms to several megohms, can be used without affecting either output level or frequency response.



Fairchild's claimed frequency response for the 215A was 20-12000 cps ±2 db, with a gradual roll off above that point and usable output at 20 kc. Our tests showed this to be a most conservative claim, and the measured response was ±2 db from 20-20000 cycles, when mounted in the Fairchild 281 arm. The extreme low frequency response is dependent on the arm, and examination of the low frequency resonance curves in our discussion of arms shows that the 215A had the smallest resonant rise of any cartridge tested.



On paper, at least, the Fairchild 215A would seem to have attained perfection. Apparently Fairchild felt otherwise, for they came out last fall with the 220 series, replacing the 215. The stylus and coil assembly were modified, resulting in increased compliance, extended (!) high frequency response, lower needle talk, and 4 to 6 db greater output, at no increase in price.

Our tests confirm all the improvements claimed by Fairchild, although their published response curve is shown as flat up to 17 kc and falling off slowly above that, with no peak.

cont. on p.16

RONETTE FF-2 REPRODUCER
(284-P Cartridge)

Last year a new line of crystal cartridges, manufactured in Holland, was marketed in this country. Claims for these Ronette cartridges featured unusually wide range, smooth response, plus a much higher compliance than any earlier crystal types. Their prices were quite low, about $7.50 (with sapphire styli, higher for diamond) for the most expensive turnover model, the 284-P.

Ronette claims an intermodulation distortion lower than 1%, which they say is less than that of any other cartridge made. They emphasize that the distortion remains at a low level at recorded velocities far in excess of any encountered in practise. Unquestionably, this would be a most desirable feature. If one reads the fine print under their curves (yes, it's all there), one learns that the 1% distortion figure is based on a continental measurement standard which becomes 4% by our American standards. Even 4% is pretty good at recorded levels of 15-20 cm/sec. However, their distortion is shown remaining at levels only slightly under 1% (or 4%) even at the lowest recorded velocities. This seemed to us rather unusual and undesirable. As we have repeatedly observed, however, curves are no substitute for listening, so we obtained a Ronette FF2 reproducer from its importers, the Ronette Acoustical Corp. and proceeded to test it. Our test information is therefore based on the performance of only this one sample.

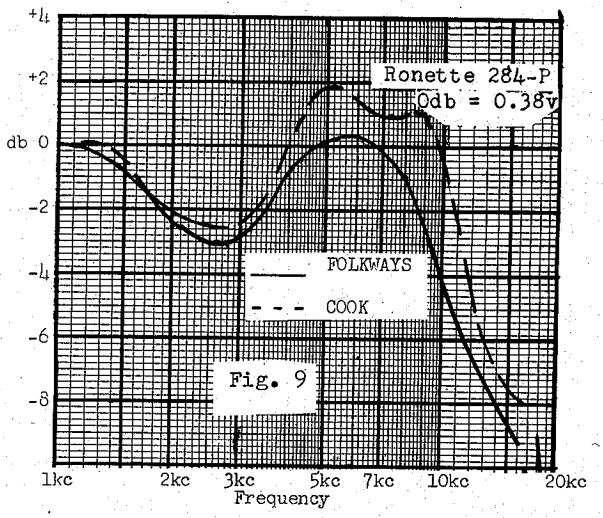
The FF2 is a remarkably light, graceful well made little arm. It consists of a polished metal tube with attractively styled ivory plastic base and cartridge shall. A spring counterbalance is provided, with a convenient adjustment of stylus pressure from 1 to 8 grams. It is equipped with a 284-P turnover cartridge, and is shipped assembled and ready to mount and use.

The overall length of this arm is about 9", which makes it ideal for compact installations. A curved finger lift gives a professional touch and indeed is the only practical method of handling such a light pickup. Ronette says that 3 grams is a satisfactory tracking pressure under level conditions, and that 1 gram has been used under laboratory conditions.

The 284-P cartridge is unique in one important respect. It is designed to give constant velocity response (just as any magnetic cartridge), when terminated in 120 K ohms. Any greater or lesser load resistor results in improper equalization. The output, when terminated in 120 K was 0.38 volts at 1000 cycles with our Folkways test record. This is much too large to feed directly into any conventional preamplifier, all of which are designed for the low output magnetic types. A home experimenter could surely design a simple one-tube preamplifier to equalize this cartridge without being overloaded, but most users will probably do as we did -- attenuate the output of the cartridge about 35 mv. and use an ordinary preamplifier.

The response curves speak for themselves. The 284-P cartridge is velocity responsive ±2 db from approximately 50 to 10,000 cycles. Response falls off fairly rapidly above 10 kc, with little getting through above 15 kc. Below 50 cycles, the output rises slightly due to arm resonance. Resonance occurs at 22 cycles, which is about the same as many arm-cartridge combinations costing several times as much as the Ronette (about $15.).

The smoothness of this curve is comparable to most magnetic cartridges, and superior to the only other prezoelectric cartridge covered in this issue (Sonotone 1P). This smoothness is quite audible, in the form of very low record scratch



and clean reproduction. In A-B listening tests, practically no difference whatever could be discovered between the Ronette FF2/284-P combination and a GE RPX-050 in a Fairchild 281 arm.

The behavior of this cartridge with the Cook Series 50 record was quite unusual. It passed the usually hazardous 14 kc region easily, then showed 2% IM distortion at 8 kc, greater than 2% at 7 kc, less than 2% at 6 kc, and greater than 2% from 6 down to 4 kc. This was apparently not dependent on stylus force. We can only surmise that this is somewhat related to the published curves showing a high residual IM distortion even at low recorded levels. In any case, our ears could not detect this distortion, and the Ronette was judged in every way the audible equal of the GE cartridge.

The biggest surprise came when we tried reducing stylus force. Starting at 8 grams, we went to 3 grams and found the tracking to be excellent. No groove skipping nor susceptibility to shock was observed at this pressure. We then reduced the pressure to 1 gram. No increase in distortion or reduction of tracking accuracy could be detected. We found some bouncing of the arm when we walked heavily, but a good shock isolation system could cure this.

So far as we know, no other cartridge will track satisfactorily at 1 gram pressure. Even the Weathers operates at 3-4 grams and depends on its brush to absorb all but 1 gram of this. This Ronette combination truly handles like a feather (even at the more conservative 3 grams). Its lateral compliance is claimed to be quite low, and the fact that, in its featherweight arm the low frequency resonance is 22 cycles, surely seems to confirm this.

This combination of high compliance and low tracking force should be extremely easy on record wear. Needle talk is very low, comparable to GE. Being a crystal cartridge, the Ronette is not subject to induced hum from magnetic fields such as exist in the vicinity of most turntable motors and would therefore permit the use of the cheaper two-pole turntable motor.

In view of all these advantages, plus its excellent sound quality, we consider the Ronette FF-2 arm and 284-P cartridge to be an outstanding buy among the lower cost pickups. It is a pity that no commercial preamplifiers can fully utilize its high output but, as we have stated, this can be easily attenuated to levels comparable to magnetic cartridges.

Incidentally, the Ronette units are claimed to be fully moisture-sealed and thus free from the usual hazards of humidity, as applied to crystal cartridges. High temperatures are still to be avoided.

COMPARISONS OF CARTRIDGE PERFORMANCE

For the convenience of our subscribers, we have made the following summary of our own relative ratings and impressions of the cartridges reported on elsewhere in this issue. Standings of the various cartridges have been determined primarily by listening tests, although a fairly close correlation will be apparent between these ratings and our laboratory measurements.

Listeners included our technical staff, their families, and numerous non-technical music lovers.

In order of majority preference:

1) ESL Professional and Concert series. These were unquestionably the smoothest, cleanest sounding cartridges we tested. Our panel's verdict was practically unanimous. Completely negligible needle talk and record scratch, plus a unique freedom from peaks and sound coloration characterize these cartridges.

2) Sharing honors for second place were the Fairchild 220A and Pickering 240. Only by an A-B comparison could the differences between them be noticed. No decisive opinions were found as to which was the better. Both are superlative by the standards of even a year ago.

3) The Fairchild 215A fell close behind the newer Fairchild 220 and Pickering 240 models. It is slightly less brilliant than the 220, a trifle less clean than either the 220 or 240. Some listeners considered it the equal of these two, others ranked it a shade behind them.

4) Pickering 140, Audak R-2 and ESL Standard series are grouped together, even though three more dissimilar sounding cartridges can hardly be imagined. All definitely were ranked below those previously mentioned and were generally considered superior to those following. The Pickering sound is strident, to the point of unpleasantness on some speaker systems. However, several listeners liked the strident effect. Needle talk and surface noise are quite pronounced. Coloration of reproduced sound is evident, frequently to the enhancement of the listener's pleasure. A high degree of "presence" is characteristic of the 140.

The Audak is quite smooth, has extremely low needle talk and very little record scratch. Its sound is more akin to that of the GE, but perhaps a bit cleaner. Almost anyone who likes a GE will find the Audak pleasing, although the reverse is not necessarily true.

The ESL Standard, which possesses many of the design features of its companion Concert series, is definitely on the "edgy" side when used without the ESL filter. Needle talk and record noise are greater than those of Audak or GE, though not as bad as the Pickering 140. With the filter, much of the "edginess" disappears from the highs (but so do the highs themselves, above 12 kc!). The sound is good, but then lacks the brilliance of the other cartridges mentioned.

There was no decided majority opinion by our listeners for or against any of these three cartridges, although individuals did have strong feelings regarding them.

5) Ronette 284-P, GE RPX 050/052 and Sonotone 1P come at the bottom of our list, through no fault of their own - their competition is rather overpowering! All three deliver first rate high fidelity performance. Indeed, the GE cartridges have for years been used as a standard of comparison. Some cartridges excelled the GE as a standard, most fell short of the mark. All the cartridges judged superior to it cost substantially more than the GE, with the exception of Ronette.

The Ronette is indistinguishable from the GE on listening tests. Its low price, plus high compliance and low tracking force, may make it a best buy in some installations. Be sure to read the report on the Ronette elsewhere in this issue for a discussion of some of its peculiarities.

Be sure to read the report on the Ronette elsewhere in this issue for a discussion of some of its peculiarities.

The Sonotone 1P ranks very close to the GE in sound quality. On A-B tests, they can be fairly easily distinguished, but after a little listening, one forgets the differences and the Sonotone 1P gives the impression of a "GE-like" sound. Its needle talk is quite similar, but record scratch is more pronounced and there is a tendency for rumble to be audible on speakers with a substantial response at 30 cycles. (We used a Karlson with the Altec 604 in most of our listening tests, as this is an acid test for turntable rumble!). The overall sound is slightly less clean on the Sonotone 1P than on the GE units.

THE DECIBEL

When describing the performance of almost any piece of audio equipment, we find ourselves all too frequently referring to decibels (abbreviated "db"), without any definition of the term. Our readers fall generally into two categories - engineers and non-technical audiophiles. The former presumably are familiar with decibel notation, but the reader without a technical background no doubt finds himself confused by this unfamiliar term.

We will not attempt any technical explanation of the decible, which would be beyond the scope of this article. We will, however, attempt to describe, in terms of audible effects, the significance of the decibel to the listener.

First, the decibel is an expression of the ratio of two power levels. Doubling the power is equivalent to a 3 db increase (this falls far short of doubling the loudness sensation). This is independent of absolute level; an increase from 0.1 watts to 0.2 watts is a 3 db increase, just as is a change from 50 to 100 watts.

The audible effect of a 3 db change is roughly the same at any level normally encountered in music reproduction. Although a 1 db power or intensity change is barely detectable, it is usually considered that 3 db is the smallest significant power or intensity change. It is common practice in radio and TV broadcasting to increase the level during a commercial. This increase frequently is from 3 to 6 db, and is usually only too apparent to the long-suffering listener.

In amplifier design, it is relatively easy to obtain a flat frequency response, so variations of more than ±1 or 2 db in the output level of an amplifier over the audible frequency range is usually indicative of an inferior product. Until very recently, phono pickups were far worse than amplifiers in this respect. Examination of the response curves elsewhere in this issue shows variations of 5 or 6 db to be quite common, even in some of the finest pickups. Speakers are the worst offenders, with peaks and valleys in their response curves of 10 to 20 db even in some of the finest and most expensive systems.

Frequently a reference is found to a signal being a number of db below some reference level, as for example in specifying hum or rumble

Cont. on page 15

AUDAK R-2

The Audak pickups are all basically variable-reluctance types. For several years two models, the R-2 and L-6, were sold. The L-6 was represented as being of professional quality. The R-2 was recommended for home use. Electrically, and physically, we have been unable to find any significant difference between them. The L-6 sold for 50% more than the R-2, so no doubt tighter quality control was applied to its manufacture.

A few years ago, with much fanfare, the "Chromatic" diamond stylus was introduced, and the L-6 so equipped became the DL-6. Audak advertising, never noteworthy for either modesty or explicitness, proclaimed this new stylus to be the crowning achievement of the pickup makers art. Its major point of difference from earlier Audak stylii (and the somewhat similar GE stylii) was an extremely thin section of the stylus bar which resulted in greater compliance than earlier models. Audak has never published data on their compliance and moving mass, except to claim "near infinite compliance and vanishing needle talk". The needle talk, while low, has a way to go before vanishing, and the compliance, needless to say, is far from infinite.

Last year the DL-6 was superseded by the Hi Q-7, a pickup of similar basic design but greater output. The output is now claimed to be 40 mv. as compared to 20 mv on earlier models.

The Audak pickups are of unique physical form. A single magnet and coil are connected to two sets of pole pieces on opposite sides of the pickup. The upper, or unused side, is protected by a "cantilever bar". Stylii are individually replaceable - an especially valuable feature if sapphires are used (which they shouldn't be!). The desired stylus is selected by rotating the entire cartridge through 180° by means of a small raised arrow on its end.

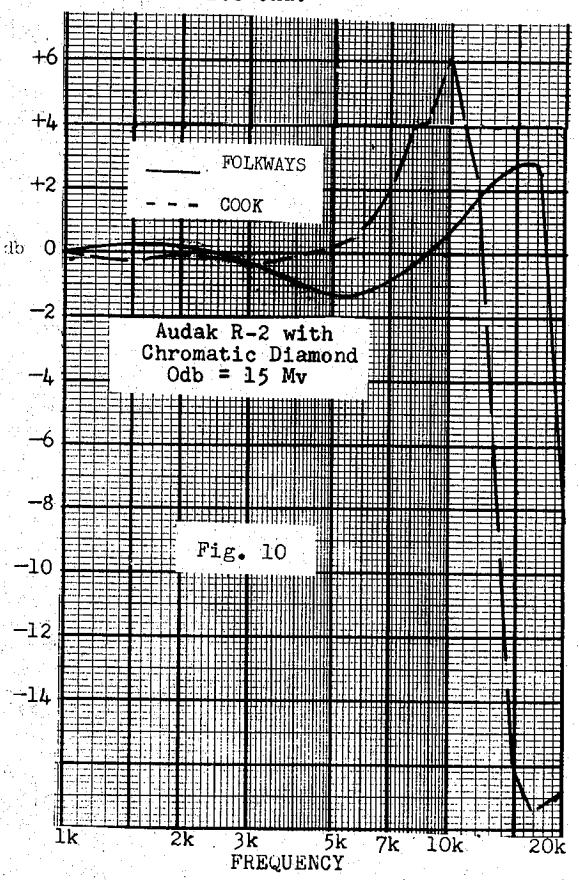


Fig. 10

The Audak cartridges are the only cartridges in the industry with a non-standard mounting. They can only be used in Audak arms (which fortunately are of good quality and unusually inexpensive) or in special shells that are available for the better record changers. The Audak is much heavier than any other cartridge we know of, and it may be necessary to modify changers slightly to reduce the tracking force to the recommended 6-8 grams. On the Garrard RC-80, for example, a turn or two must be clipped off the spring which sets the stylus pressure.

The design of Audak cartridges is such that no magnetic attraction exists between them and steel turntables. The designer of the Audak, Maximilian Weil, was instrumental in bringing this problem before the public, referring to it as "hidden pull". Naturally, this was in the nature of a plug for Audak, but there were many people who would never have realized their records were being destroyed by excessive stylus pressure if Weil's ad had not brought the problem to their attention. As a matter of fact, most cartridges are just as free from "hidden pull" as the Audak. (One of the worst offenders is Fairchild, but a 1/8" foam rubber pad on the turntable usually cures the difficulty).

One thing Audak ads somehow fail to point out is its remarkable susceptibility to hum pickup. On a Garrard RC-80 changer, for example, as the Audak cartridge approaches the innermost grooves of a record, the induced hum from the motor field becomes quite audible. Replace the cartridge with a GE (or Fairchild, or Pickering), and the hum disappears. We have even observed an annoying hum pickup on the Audak when using a Rek-O-Kut T-12 turntable.

The pickup we tested was an R-2 whose electrical parameters were measured and found to be identical to those of the L-6. It was equipped with a "chromatic" diamond stylus, identical to those supplied on the DL-6 and HiQ-7. Since it was an R-2, however, we cannot offer the test data as necessarily being representative of their later models. It is therefore presented for general information only.

Our earlier response curves, taken with the Cook #10 record, showed a sharp high frequency cut-off above 12 kc. The Folkways record, on the other hand, showed the high frequency cut-off occurring at 18 kc. As we explained in the discussion of test records, this is probably due to differences in record material compliance and the actual upper limit of the pickup on various records probably will vary from 12 to 18 kc. The outstanding feature of these response curves is the extremely sharp cut-off - much more rapid than any other pickup we have encountered.

It should be noted that the output was well below the claimed 20 mv - lower, in fact, than several GE pickups we tested.

Audak advertising stresses "listening quality". Having lived with an Audak pickup for several years, and having compared it to almost every other pickup on the market, we can say that its listening quality is good, but undistinguished. It definitely is superior to the GE, particularly in the clarity of the highs, but hardly by a wide enough margin to warrant its extra cost ($41. vs. $22. for the diamond-sapphire combination). The feature of individually replaceable stylii is valuable under certain conditions, but current GE models offer the same feature. Its needle talk is very low, at least as good as GE and superior to most other pickups.

Audak pickups have one advantage over all the others (except ESL). The stylus is clearly visible without the necessity of peering under the cartridge. Cueing is simply accomplished without having to make several attempts to locate the desired groove.

cont. on p.16

SONOTONE 1-P

A serious weakness of conventional crystal cartridges is their deterioration when exposed to a humid atmosphere or to temperatures over 100°F. For a number of years there have been ceramic cartridges on the market which do not have this disadvantage. These normally employ a barium titanate element which performs electrically almost identically to the Rochelle salt crystals, but is unaffected by humidity and temperatures ordinarily encountered.

Unfortunately, most of these ceramic cartridges were designed and intended for the ordinary home receiver market as replacements for crystal cartridges. Their response characteristics were equivalent to the units they replaced, which is to say unspeakably bad.

Several years ago, Columbia introduced their 360 phonograph, which set a new standard of sound reproduction for low cost home phonographs. A new wide range ceramic cartridge developed by Sonotone (a pioneer in ceramic transducers) was a key part of this system. It tracked at pressures of grams instead of ounces, was compliant enough to give records a reasonable chance for survival, and in general merited inclusion in the ranks of high fidelity pickups.

This cartridge was made commercially available, with a unique turnover stylus structure, as Model 9980. It retailed for $5.70 with two sapphire stylii or $20.40 with a diamond-sapphire combination. It featured a lateral compliance greater than 0.9×10^{-6} cm/dyne, tracking force of 9 grams, output of approximately 1 volt on microgroove records, and built-in equalization to a compromise curve suitable for most recording characteristics. A typical cartridge would fall within ±3 db of the RIAA or Columbia LP curves from 30-10,000 cycles, but production tolerances were broad enough so that, at the extremes of frequency, as much as ±5 db variation was possible.

Last fall, a new single stylus model, the 1P, was introduced. This was intended to provide a higher order of performance than the 9980. It had a compliance of 1×10^{-6} cm/dyne (equivalent to a GE variable reluctance cartridge), a 1 volt output, 8 gram tracking force, and response claimed to follow the RIAA curve ±3 db from 30-15,000 cycles. The price of the 1P is $5.10 with sapphire, or $18. with diamond. It is available with 1 mil or 3 mil stylii, which are easily replaced by the user.

The Audio League tested several samples of both 9980 and 1P cartridges as well as the newer 2T (identical to the 9980 except for mounting brackets). As the response curves show, there is virtually no difference between the frequency response of the 2T and 1P models. The 1000 cycle output level was 0.90 volts for the 1P and 0.98 volts for the 2T, on the Folkways record, and slightly less with the Cook record.

These response curves were taken with the cartridge feeding directly into a Hewlett-Packard 400C Vacuum tube voltmeter, which presented a 10 megohm load. Cable capacitance was about 100 mmf. Under these conditions, the bass response is at a maximum. It should not suffer too badly if a 2 megohm load is used, but this is a minimum value for a hi-fi application.

From the superimposed RIAA equlization curve, it can be seen that both cartridges (2T and 1P) do give excellent equalization for this characteristic. The 2T, having much less compliance with the 1P, resonates around 30 cycles with the B-J arm and parts company with the record at that point! From 40-10,000 cycles, however, it certainly falls within 3 db of the RIAA curve. On the other hand, the 1P doesn't resonate (nor jump out of the groove) until the 16 cycle region, and its response is within 3db of the RIAA curve down to at least 22 cycles, which substantially exceeds the manufacturer's claimed performance. The compliance of the Sonotone 1P, judging from this measurement, would seem to be greater than that of the Fairchild 220, which resonated at 22 cps in the same B-J arm. However, the latter stayed with the record at resonance, whereas the Sonotone jumped grooves - obviously not as well damped.

On the high end, both Sonotone cartridges held up well to 10 kc! Beyond that point, the output levels fell so low that they were masked by hum and rumble and could not be measured.

The cartridges were mounted in a B-J arm and in listening tests were compared A-B with a Fairchild 220A or a GE RPX-050, mounted in a Fairchild 281 arm. A Karlson enclosure with Altec 604 speaker was used in this test. Our regular phono preamp was set for RIAA equalization of the magnetic cartridges.

Perhaps the most striking difference between either ceramic cartridge and either magnetic was the record scratch. This was very low with the Fairchild, slightly greater with the GE, distinctly greater with the 1P, and still more prominent with the 2T! Examination of the response curve will show the peak of several db at 6 kc which is most probably the cause of the higher scratch level.

The rumble was also audible at high levels with the Sonotone cartridges (using a ReK-O-Kut T-12 turntable) although it could not be detected with any of the magnetic cartridges. Most likely this is due to the ceramic units having some response to vertical stylus motion, while the magnetic have practically none.

Needle talk was quite low on the Sonotone cartridges, comparable to most magnetic units.

The 2T failed to pass the Cook Series 50 record, while the 1P passed easily. We believe its higher compliance played a considerable part in this.

On music, the 1P showed a clear superiority over the 2T. The latter was not in the class of the other high fidelity cartridges we tested. On the other hand, the 1P proved itself to be worthy competition for the GE cartridge. Apart from its higher record scratch level, the sound quality of the 1P was not too different from that of the GE. They could be easily told apart in A-B comparisons, but on many records neither one could be said to outshine the other. However, on some heavily recorded passages or those with a preponderance of high frequency, the GE sounded somewhat cleaner.

At another time in our test program, we connected the Sonotone 1P directly to the 15K input resistance of our preamplifier. Normally, when an amplitude responsive pickup is so connected its output characteristic becomes similar to that of a velocity responsive pickup. In this manner of operation its output can then be equalized as if it were a magnetic cartridge.

The Sonotone cartridges are not truly amplitude responsive, since they are internally equalized for the RIAA curve. As a result, there is a hole in the mid-frequency range which would be rather difficult to compensate. The high frequency response was phenomenally good, however. and we believe it indicates the potentialities of this cartridge in its conventional mode of operation. Our measurements showed it to be flat ±1 db from 10 kc to 18 kc and down 3 db at 20 kc on the Cook record. Only that peak at 6 kc remains to mar an otherwise near-perfect response.

cont. on next page.

Sonotone, cont.

We understand that Sonotone is going to have a new cartridge on the market this summer which does not have the peak at 6 kc and is flat within 2 db from 30-15,000 cycles. Its compliance is reputed to be considerably higher than that of the 1P. We would hazard a guess, based on our experiences with the 1P, that this new job will give a lot of magnetic cartridges a run for their money. We plan to test it when it becomes available.

We are sure many readers are wondering what advantages a ceramic cartridge offers over a magnetic type in their own systems. With almost any existing commercial amplifier, we are forced to state that there would be no advantage to a ceramic, since a preamplifier equalizer for magnetic cartridges is already built into almost all commercial amplifiers. To our way of thinking, the elimination of a preamp and equalization controls is the cardinal feature of ceramic cartridges. What is needed now is a <u>low cost</u> amplifier designed to accept the output of a ceramic cartridge, possibly including tone controls designed to modify the response for other record curves than the RIAA (the need for such controls is debatable, however).
Sonotone manufactures an amplifier designed to utilize their cartridges - particularly the one expected this summer. We have not yet tested this amplifier but Sonotone makes substantial claims regarding its performance. Its price, however, is quite high considering it has no preamp (which it doesn't need). We would like to see a 10 watt amplifier of the sort we have described, possibly also including a loudness control, selling for $50. It can be done. Who will be the first to capture this market?

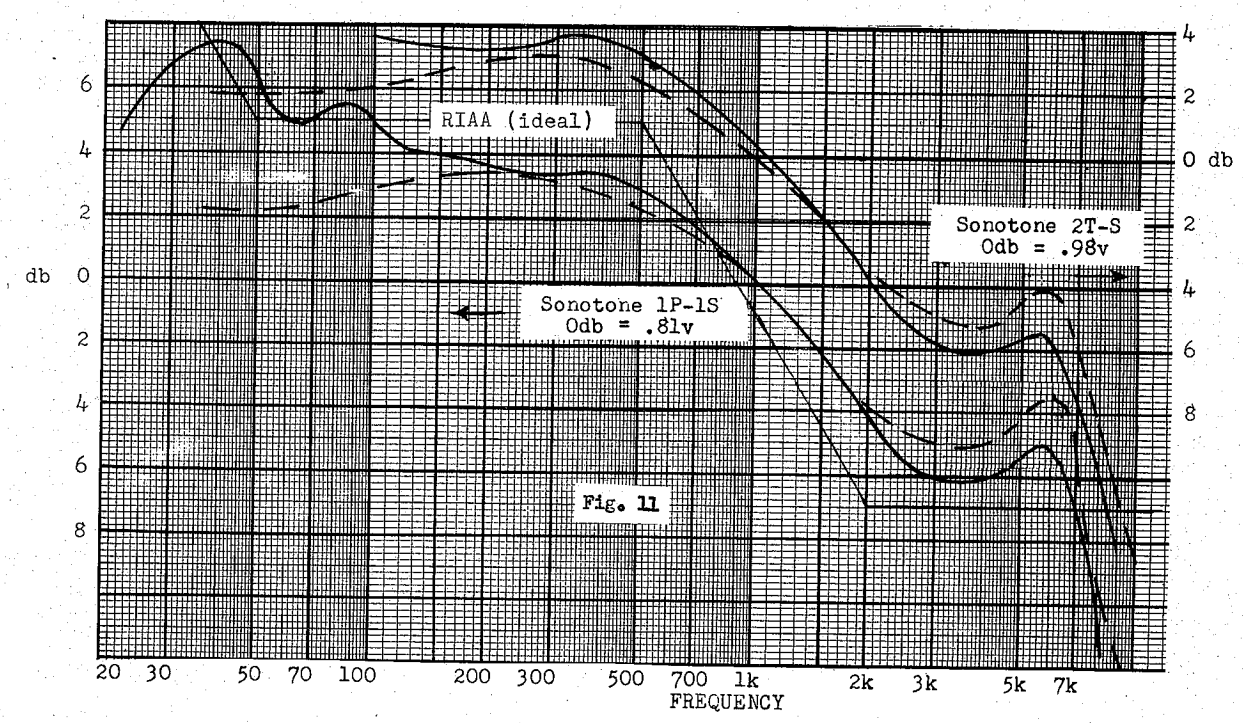


Fig. 11

<u>Decibels, cont.</u>

levels. The accompanying table shows the relationship between db values and power or voltage levels:

db	Power	Voltage
2	1.6	1.3
3	2	1.4
5	3.2	1.8
8	6.3	2.5
10	10	3.2
15	31.6	5.6
20	100	10
30	1000	31.6
40	10000	100
50	100000	316
60	1 million	1000
70	10 million	3162
80	100 million	10,000

For example, an amplifier whose hum level is 80 db below 10 watts has a hum output of 1/100,000,000 times 10 watts, or 0.1 microwatts. A normal home listening environment, a hum level of -70 db/10w or 1 microwatt is barely audible when standing close to an efficient speaker. Levels of -80 db or lower are completely inaudible.

Similarly, a turntable with a rumble level 40 db below an average recording level of, perhaps 8 cm/sec. will generate a voltage in a pickup equivalent to a signal 1/100 times 8 cm/sec, or 0.08 cm/sec. (Recorded velocity is equivalent to voltage rather than power).

In describing sound levels, a standard reference level of sound pressure has been established. A pressure of 0.0002 dynes/cm^2 at 1000 cycles is called 0 db. A quiet home background noise level may be 40 db. Soft background music may be at a 60 db level, while most people listen to their hi-fi systems at a 70-80 db level. Above 90 db we approach lease-breaking volumes and 120 db is near the threshold of pain. Even dyed-in-the-wool hi-fi addicts usually flinch before the onslaught of a 120 db sound level. This is not surprising since a full symphony orchestra can only develop a momentary maximum of about 110 db at the conductor's podium.

It should be obvious from the preceding examples that the subject is rather complex, but that the notation conveys a definite ratio relationship quite clear to the engineer and comprehensible to the layman.

Fairchild, cont.

We found the usual resonant peak, at 13-15 kc. instead of 12 kc, as in the 215, and with an amplitude of approximately 3 to 5 db. The rise is gradual, starting at 6 or 7 kc, so the record hiss is not accentuated by the peak. We found the 220 to be the same as the 215 in this respect.

The general rise in the higher frequencies gives it a more brilliant sound than its predecessor. A definite though not major improvement in definition of complex orchestral passages was observed. On the low end, the arm resonance was at a somewhat lower frequency; we would estimate the compliance to be about 50% greater than that of the 215, or about 2.7 x 10^{-6}cm/dyne. (This is our rough guess, not based on any information from the manufacturer). However, the amplitude of the resonant peak at 13 cycles is greater than 10 db, and the cartridge jumped out of the groove at this point on our Folkways test record.

The output increase (8 mv., or 6 db more than our 215A) is one of the most important features of the 220. Any preamplifier can be used with this that can operate from a CE cartridge. The impedance of the cartridge is still quite low (170 ohms) and resistive, so it is insensitive to terminating resistance, shunt capacitance, and hum pickup. Needle talk of the 220 is substantially lower than that of the 215.

Although the 215 is no longer being manufactured, it may still be available from some dealer's stocks. Many dealers have been closing them out for $20. We consider them an unbeatable value at that price.

The 220 is one of the top three cartridges we have tested. It is noticeably superior to the 215 on some of the better records and indistinguishable from it, on most records. We have been asked whether it would be worthwhile for a 215 owner to get rid of it in favor of a 220. The staff (with several satisfied users of the 215) does not feel that this change is, in general, warranted. The improvement would not be commensurate with the expense. Those with extra funds and the determination to keep their equipment up-to-date with the latest and best will probably want to make the change anyway.

Audak, cont.

Summarizing, we find the Audak to be one of the better variable reluctance pickups (we would rate it between the GE and the Pickering 260), having the convenient features of separate stylii individually replaceable by the user, extreme ease of cueing, and low needle talk.

On the other hand, it requires a special arm and is unusually subject to hum pickup. Price-wise, it falls between the GE and Pickering 260.

* * * *

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COMING SOON

Space limitations prevented inclusion of several features which we had hoped to fit into this issue. These will be presented next month. Among them will be a discussion of tone arms with specific reports on ESL 310, B-J, Weathers, and Pickering 190D. Reports on the Weathers Debonnaire system and the Electro-Voice 84-P ceramic cartridge are also planned for early release.

Among the other reports in progress are those on the REL Precedent and Craftsman C-900 FM tuners, Pilotone AA-904 amplifier, National Catenoid speaker system, Acoustic Research AR-1 speaker system, and the Karlson enclosures.

We would like, at this time, to apologize to Karlson Associates for publicly doubting (see November, 1954 Report) that they could deliver a 16 cycle fundamental output. We proved to ourselves that it can do this -- in fact, its bass response can only be described as phenomenal. Our complete report on these controversial speaker enclosures will be of great interest to many of our readers. Watch for it in an early issue.

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